PART 14

INSPECTION, TESTING AND COMMISSIONING REQUIREMENTS

CONTENTS

PART-14

14.1 INSPECTION AND TESTING DURING MANUFACTURE 2
14.1.1 General *2*
14.1.2 Materials, Plant, and Equipment *7*
14.1.3 Factory Acceptance Test (FAT) Document *8*
14.1.4 Inspection and Testing Programme *9*
14.1.5 Tests at Manufacturer's Premises – Mechanical Equipment *10*
FIELD TEST 15
14.2 MECHANICAL EQUIPMENT 19
14.3 TESTS AT SITE 19
14.4 PUMPS, PIPING AND VALVES 20
14.5 MOTORS 20
14.6 CRANES 20
14.7 SCREENS 21
14.8 GATES 21
14.9 REINFORCED CEMENT CONCRETE PIPES 21
14.10 STEEL CYLINDER PIPES AND SPECIALS 21
14.11 CAST IRON, DUCTILE IRON PIPES AND FITTINGS 22
14.12 MANUFACTURER'S WORKS ACCEPTANCE TESTS ON ELECTRICAL EQUIPMENT 24
14.13 MANUFACTURER'S WORKS ACCEPTANCE TESTS ON INSTRUMENTATION, PLC, SCADA AND ASSOCIATED EQUIPMENT .. 24
14.14 MANUFACTURER'S WORKS ACCEPTANCE TESTS ON UNINTERRUPTIBLE POWER SUPPLIES 33
14.15 INSPECTION AT SITE 33
14.16 PLANT PROTECTION ON SITE 33
14.17 ERECTION STAFF 33
14.18 ERECTION AND BUILDING-IN 34
14.19 CIVIL INSPECTION (WATER LEAKAGE TEST) 36
14.19.1 Tanks and basins *36*
14.19.2 Field Control Inspection *36*
14.19.3 Inspection after Erection *36*
14.20 SITE ACCEPTANCE TEST DOCUMENT 38
14.21 TESTS ON COMPLETION 38
14.21.1 General *38*
14.22 DRY TEST REQUIREMENTS 42
14.23 PROCESS PLANT ITEM / EQUIPMENT 43
14.24 HYDRAULIC WET TEST REQUIREMENTS 43
14.25 SAFETY AUDIT 44
14.26 PROCESS WET TESTS (WITH RAW SEWAGE) 44
14.27 EFFLUENT QUALITY CRITERIA FOR PASSING THE TESTS ON COMPLETION 45
14.28 CO-OPERATION WITH OTHER CONTRACTORS IN THE EXECUTION OF THEIR TESTS 45
14.29 TESTS AFTER COMPLETION 45
14.30 PERFORMANCE CERTIFICATE 48

PART 14

INSPECTION, TESTING AND COMMISSIONING REQUIREMENTS

14.1 Inspection and Testing During Manufacture

14.1.1 General

(a) All inspection and testing shall be carried out for 100% quantity of equipment in accordance with the Specification and in absence of Specification relevant Indian Standard or internationally approved equivalent standard. After award of contract, Contractor shall furnish a QA plan for approval by Employer along with every datasheet. QA plan shall include testing for incoming supply of raw materials and bought out items, stage inspections and tests on finished products at manufacturer's works where the equipment has been manufactured.

(b) **Inspection and tests schedule shall be as follows;**

1) Manufacture tests
2) Acceptance inspection/ Quantity checking
3) Install/ site inspection
4) Site acceptance test
5) Tests on Completion
6) Process Wet Tests (by Raw Sewage)
7) Operation Test (Tests After Completion)
8) Complete performance tests of Plant after seven-year Operation (Before plant handing over)
9) Test furnished as per IS Code/manufacturer QAP

(c) The Contractor shall carry out at the place of manufacture, tests of the Plant /Equipment at any part of the Works as per approved QAP.

(d) The Employer and duly authorised and designated representative(s) shall be entitled to attend the aforesaid inspection and/or tests.

(e) The Employer and his duly authorised representative shall have access to the Contractor's premises at all times to inspect and examine the material and workmanship of the mechanical and electrical and ICA plant and equipment during its manufacture there. If part of the plant and equipment is being manufactured on other premises, the Contractor shall obtain permission for the Employer or his duly authorised representative, to inspect as if the plant and equipment was manufactured on the Contractors own premises. Testing (including testing for chemical analysis and physical properties) shall be carried out by the Contractor and certificates submitted to the Engineer who will have the right to witness or inspect the above mentioned inspection /testing at any stage desired by him. Where inspection or testing is to be carried out at a subcontractor's works, a representative of the Contractor shall be present.

(f) Contractor shall provide test procedure, pre-factory test results, and calculation sheet, photo in advance and provide all of test result with necessary document including its data and photo to show Engineer that test is carried out in proper condition. Construction material shall be tested by contractor at the approved laboratory.

(g) The procedure for the testing and inspection to be carried out during or following the manufacture of the materials to ensure the quality and workmanship of the materials and to further ensure that they conform to the Contract in whatever place they are specified shall be as described below.

(i) The Contractor shall give the Employer at least 21 clear days notice in writing of the date and the place at which any plant or equipment will be ready for inspection/testing as provided in the Contract. Prior to notice, contractor should submit pre factory test results as per clause 14.1.1(f). The Employer or his duly authorised representative shall thereupon at his discretion notify the Contractor of his intention to inspect. The employer shall then give notice in writing to the Contractor, and attend at the place so named the said plant and equipment which will be ready for inspection and/or testing. As and when any plant shall have passed the tests referred to in this section, the Engineer shall issue to the Contractor a notification to that effect after obtaining clearance from the consultants.

(ii) The Contractor shall forward to the Employer 6 duly certified copies of the test certificates along with characteristics performance curves/tables if any for all equipment obtaining dispatch clearance from the consultants/Engineer.

(iii) If any materials or any part of the works fails to pass any inspection / test, the Contractor shall either rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice as per (i) above. Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

(iv) Where the plant and equipment is a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the manufacturer's works.

(v) Neither the execution of an inspection test of materials or any part of the works, nor the attendance by the Engineer (s), nor the issue of any test certificate pursuant to (iii) above shall relieve the Contractor from his responsibilities under the Contract.

(vi) The test equipment, meters, instruments etc., used for testing shall be calibrated at recognised test laboratories at regular intervals and valid certificates shall be made

available to the Engineers at the time of testing. The calibrating instrument used as standards shall be traceable to National/International standards. Calibration certificates or test instruments shall be produced from a recognised/Laboratory for the Engineer's consent in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test.

(vii) Items of plant or control systems not covered by standards shall be tested in accordance with the details and program agreed between the Engineer and Contractor's Representative. If such materials or works are found to be defective or not conforming to the Contract requirements, due to the fault of the Contractor or his sub-contractors the Contractor shall defray all the expenses of such inspection and/or test and of satisfactory reconstruction.

(viii) Tests shall also be carried out such that due consideration is given to the Site conditions under which the equipment is required to function. The test certificates shall give all details of such tests.

(ix) The Contractor shall establish and submit a detailed procedure for the inspection of materials or any part of the works to the Employer for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following :

- Applicable code, standard, and regulations.
- Fabrication sequence flow chart indicating tests and inspection points.
- Detailed tests and inspection method, indicating the measuring apparatus to be used, items to be measured, calculation formula, etc.
- Acceptance criteria.
- Test report forms and required code certificates and data records.
- Method of sampling, if any sampling test to be conducted.
- Contractor's or Employer's witness points.

(x) The Contractor shall not pack for shipment any part of the Plant until he has obtained from the Employer or his authorised representative his written approval to the release of such part for shipment after any tests required by the Contract have been completed to the Employer's satisfaction.

(xi) The following Inspection and Testing procedures shall be carried out for the equipment as per approved QAP.

The detailed procedure shall indicate or specify, without limitation, the following:

- Raw Material
- Visual Inspection/Appearance.
- Chemical and Mechanical property tests

- Dimension Checking
- Static & Dynamic balancing for all rotating parts
- Stage inspection & functional check
- Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable
- Repair procedure
- Operation check
- Procedure Qualification Record (PQR); Welding Procedure Qualification (WPQ) and Welders Qualification Report (WQR)
- Material Test
- Assembly/Connection
- Documentation

(h) The Contractor shall maintain proper identification of all materials used, along with reports for all internal / stage inspection work carried out, based on the specific job requirement and or based on the datasheets / drawings / specifications.

(i) The expenses incurred during inspection shall include, but not be limited to all travelling, boarding, lodging and out-of- pocket expenses.

(1) The Contractor shall be responsible for all expenses incurred by the Engineer or person/s nominated by the Engineer in attending inspection and tests of Plant carried out during manufacture within India and outside India. Two engineers from Employer & one engineer from employers representative will witness the Inspection and testing at the manufacturer's works where the equipment has been manufactured, along with the contractor's representative.

(2) Cost of inspection when material or any part of the facilities is not ready at the time specified by the Contractor for inspection or when re-inspection is necessitated by prior rejection shall also be borne by the Contractor.

(j) Witnessed testing will normally be waived on standard types of equipment such as small motors made by approved manufacturers, individual standardised instruments (Pressure gauge, pressure switch, level switches, Rotameters and cable trays) small mass produced components used in the manufacture of Plant items, small bore pipework and fittings, minor installation materials and low voltage cable. In order to remove doubt this shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.

(k) As a guide to the Contractor the Employer reserves the right to witness, testing of the following on a minimum at manufacturer's test facility where the equipment has been manufactured, but not limited to the following Plant items:

a) Electrical:

(1) Transformers
(2) 11 kV Metal enclosed switchboards & Switchgears.
(3) 415 V Metal enclosed switchgears (PCC)/ MCC
(4) 415 V Power capacitor and control panel
(5) Diesel Standby Generator with AMF Control Panel
(6) Battery, battery charger and DC Distribution Board
(7) Variable Frequency Drives
(8) Non Segregated Bus Duct
(9) Power & control cables
(10) Lighting System

b) Mechanical:

(1) Storage and process vessels
(2) Grit Mechanism
(3) sludge/scum mechanisms
(4) Chemical dosing systems complete with pumps, valves & tanks.
(5) Submersible Mixers, Alum dispersion mixers, Agitators, Screw/Lobe pumps, Submersible/Centrifugal Pumps and blowers including their motors, Sludge pumps, scum pumps, Recycle pumps, Plant Water Pumps, Plant Drain Pumps.
(6) Valve and Sluice gate actuators.
(7) All type of Valves
(8) All Type of Pipes & fittings
(9) Sluice Gates
(10) Expansion/Dismantling Joints.
(11) Weir Gates & Stop logs.
(12) ISPS Coarse Screens and STP Medium/Fine Screens, Step screens
(13) Chlorination system
(14) Process Air Blowers
(15) EOT Cranes and Hoists
(16) Heat Exchangers
(17) Scraper Mechanism (Collector Mechanisms)
(18) Bio Media (IFAS)
(19) Belt Conveyor
(20) Disc Filter

c) Instrumentation and Control:

(1) Level Measuring System
(2) Pressure Transmitter
(3) Flow Measuring System
(4) Temperature Measuring System
(5) Instrumentation and Control Cables

(6) Instrument Control Panel
(7) Complete Control & Automation system
(8) All Analytical Instrumentation (DO, ORP, MLSS, Residual Chlorine, etc…)
(9) Laboratory equipment's, Real time online Influent & effluent systems,
(10) Auto sampler systems
(11) Uninterruptible Power Supply System
(12) Factory acceptance test (FAT) for complete control & Automation component (PLC & SCADA combined)
(13) SAT for complete ICA system & plant systems

(l) All destructively tested samples shall be replaced with new.

(m) The Employer reserves the right to be present during the testing and inspection of all Plant items.

14.1.2 Materials, Plant, and Equipment

The Contractor shall place orders for the material and the equipment only after approval QAP by the Engineer. The Contractor shall submit the detailed technical and its drawings from the approved manufacturer and the procedure of submission, review and revision shall be as specified herein below.

The Contractor shall inform the Employer about the likely dates of manufacturing, testing, and dispatching of any material and equipment to be incorporated into the Permanent Works. The Contractor shall notify the Employer for inspection and testing, at least twenty-eight (28) days prior to packing and shipping and shall supply the manufacturer's test results and quality control certificates.

The following inspection and test categories shall be applied prior to delivery of the equipment, of various categories as indicated in the technical specifications for each type of the equipment:

Category A: -The drawings have to be approved by the Engineer before manufacture and testing. The material has to be inspected by the Engineer or a third party inspecting agency approved by the Employer at the manufacturer's premise before packing and dispatching.

Category B: - The drawings of the equipment have to be submitted and approved by the Engineer prior to manufacture. The material has to be tested by the manufacturer and the manufacturer's test certificates are to be submitted and approved by the Engineer before dispatching of the equipment. Notwithstanding the above, the Employer, after examination of the test certificates, reserves the right to instruct the Contractor for retesting, if required, in the presence of the Contractor's representative.

Category C: - Samples of the materials and/or equipment shall be submitted to the Engineer for pre-construction review and approval in accordance with the provisions of Sub-Clause 5.5, Section 2. Following approval by the Employer, the material may be manufactured as per the approved standards and delivered to the Site.

For material/equipment under Category "A" and "B", the Employer will provide an authorization for packing and shipping after inspection.

The testing and approval for dispatching shall not absolve the Contractor from his obligations for satisfactory performance of the plant.

Dispatch Clearance

All mechanical/electrical/instrumentation, control & automation equipment shall be tested at their respective factory where the equipment has been manufactured, which will be witnessed by tri parties (Contractor, BWSSB/Consultant inspecting team) in line with approved QAP and Equipment Data sheet.

The test observation sheets, material tests certificates (chemical and mechanical test at laboratory) and joint inspection report shall be signed by the Contractor, BWSSB/Consultant officials after successfully completion of tests.

Contractor shall forward all original reports to BWSSB and copy to Consultant for verification and issuances of Dispatch Clearance Certificates as per clause 14.1.1 g (ii). No Dispatch Clearance Certificate will be issued at the factory itself by the inspecting agency.

14.1.3 Factory Acceptance Test (FAT) Document

Twenty one (21) days prior to commencement of inspection of each Plant item / equipment the Contractor shall supply a Factory Acceptance Test (FAT) Document for approval. This shall comprise four copies of the following:

- Unpriced copy of the Contractors order for the Plant item / equipment concerned:
- Details of the inspection and test procedures to be carried out.
- Pre-factory test results and its photos.

The FAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT shall provide space within the documentation for results of the tests to be added and for each test and for the FAT as a whole to be signed off by the Contractor and the Engineer.

On completion of the tests the Contractor shall provide Six copies of all test certificates, curves etc. for the inspected Plant item. To remove doubt test certificates shall be provided for the Plant item as a whole plus certificate for the relevant component parts such as:

(1) Storage and process vessels

(2) Grit Mechanism
(3) sludge/scum mechanisms
(4) Chemical dosing systems complete with pumps, valves & tanks.
(5) Submersible Mixers, Alum dispersion mixers, Agitators, Screw/Lobe pumps, Submersible/Centrifugal Pumps and blowers including their motors, Sludge pumps, scum pumps, Recycle pumps, Plant Water Pumps, Plant Drain Pumps.
(6) Valve and Sluice gate actuators.
(7) All type of Valves
(8) All Type of Pipes & fittings
(9) Sluice Gates
(10) Expansion/Dismantling Joints.
(11) Weir Gates & Stop logs.
(12) ISPS Coarse Screens and STP Medium/Fine Screens, Step screens
(13) Chlorination system and Cl_2-Gas Scrubbers
(14) Process Air Blowers
(15) EOT Cranes and Hoists
(16) Heat Exchangers
(17) Scraper Mechanism (Collector Mechanisms)
(18) Bio Media (IFAS)
(19) Belt Conveyor
(20) Disc Filter

14.1.4 Inspection and Testing Programme

The Contractor shall submit to the Engineer not later than 56 days prior to the commencement of the first inspection and test during manufacture a programme detailing the inspection dates for all Plant. Those items of Plant that the Engineer has specifically identified for witness testing test shall be highlighted in the programme.

The Contractor shall keep the Engineer informed of any changes to the programme.

The Engineer shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Employer’s Requirements.

The Contractor shall inform the Engineer in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Engineer after the receipt of the above case equipment/material etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the Employer for such visits shall also be recovered from the Contractor. Contractor's Representatives shall essentially be present during all inspections of Plant items. The following information shall be given in the inspection call letter mentioned above:

(a) Name of manufacturer/supplier;

(b) Address of place where inspection is to be carried out;

(c) Proposed date/s and equipment to be inspected;

(d) Name/s of contact personnel at manufacturer's/ supplier/s works with their telephone and fax numbers.

(e) Name of Contractor's Representative who will be present during the inspection.

(f) Confirmation that internal testing has been completed. Submission of internal testing report for review before visiting the plant

The Contractor shall provide all the necessary instruments, test facility, water / electric power, test piece, samples, engineers/ workers, all cost and others to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by and approved by an independent testing authority not more than one month prior to the tests in which they are used. Calibration certificates with expire date and name of authorization agency for instruments used for such tests shall be produced for the approval of the Engineer and if necessary, instruments shall be recalibrated before the commencement of the tests.

No material shall be delivered to the Site without Dispatch clearance certificate having been carried out or waived in writing by the Engineer.

If during or after testing, any item of plant fails to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and retested and re-inspected as required by the Engineer.

All the equipment shall be inspected & tested with respect to the approved standards and norms at manufacturer’s place.

14.1.5 Tests at Manufacturer's Premises – Mechanical Equipment

14.1.5.1 Sewage / Sludge and Other Pumps

(a) All pumps shall be assembled completely in the shop to ensure correct fitting of all parts and shall be match-marked before shipment.

(b) All pumps shall undergo witness performance tests at the pump manufacturer’s Works. Testing shall be undertaken with the respective job motor for all the pumps being supplied under the

Contract. The Extent of witness will be decided by the Client/consultant for which contractor should adhere.

(c) All tests such as Q/H curve, efficiency of pumps, power consumption, vibration and noise level shall be conducted, and NPSH tests one for each pumping station shall be undertaken to verify that the pumps meet the specified criteria. The pumps shall be run at constant flow capacity and speed.

(d) Pump casings shall be subject to hydrostatic pressure testing as an assembly at 150% of the pump shut-off head or 200% of the pump rated head whichever is higher. The hydrostatic pressure shall be held for not less than 30 minutes after all leaks have been stopped between attachments.

(e) Impeller and pump rotating assembly shall be dynamically balanced as per ISO 1940 / Gr. 6.3 / VDI 2060.

(f) Standard running test shall be conducted as per BS 5316 Part 2 Class B / ISO 3555 at the rated speed at manufacturer's works to measure the capacity, total head, efficiency and power. These tests shall form the basis for pump acceptance except for vibration and noise. The pump shall be tested over a range comprising shut off head to maximum flow. Minimum seven readings approximately equidistant shall be taken for plotting the performance curve.

(g) The following formula shall be taken for computing the power input to the pump:

$$\text{Power input to the Pump in kW:} \quad \frac{Q \times Hx1.02}{367.2 \times \eta_p}$$

Where, Q = Discharge in cum/hr
H = Total head in mwc
η_p = Efficiency of pump

(h) If the vibration, noise level readings taken during performance test show higher than that permitted, vendor shall guarantee to show that the values shall be maintained at site after erection. Any cost of rectification needed on this count shall be borne by the Contractor.

(i) Stage inspection for pumps shall be carried out as per approved QAP. The Contractor has to make all necessary arrangement for witnessing the same.

(j) The efficiency quoted in the technical schedule shall be without negative tolerance.

14.1.5.2 Motors

(a) Routine Tests
All routine tests shall be carried out on all motors as per the latest edition of IS 325.

(b) Acceptance Tests
Full load test to determine efficiency, power factor and slip shall be conducted on all the motors.

(c) Type tests

The following type tests shall be carried out on one motor of each rating above 5 kW.

(1) Isolation resistance test
(2) Temperature rise test
(3) Momentary overload test
(4) Vibration measurement test
(5) Noise level test
(6) Over speed /over load test
(7) Starting current, starting torque, and pull out torque at reduced voltage

14.1.5.3 Valves and Expansion Joints

(a) During testing there shall be no visible evidence of structural damage to any of the valve component.

(b) Motorized valves shall be tested with their job actuator, with a differential head equivalent to their maximum working pressure, to prove that the actuators are capable of opening and closing the valves under maximum unbalanced head condition within the specified opening or closing period.

(c) Hydrostatically tested shall be as per relevant IS/BS standard for each type of valve.

(d) The following test shall be carried out for sluice, Plug, Ball and Knife Gate valves:

(1) Seat leakage test.
(2) Body hydrostatic test.
(3) Valve operation.
(4) Dimensional Check.
(5) Visual Inspection.

(e) The following test shall be carried out for non-return valves:

(1) Seat leakage test.
(2) Body hydrostatic test.

(3) Valve operation
(4) Dimensional Check.
(5) Visual Inspection.

(d) The following test shall be carried out for Expansion Joints:

(1) Leakage test.
(2) Body hydrostatic test.
(3) Displacement range.
(4) Dimensional Check.
(5) Visual Inspection.

14.1.5.4 Pipe-work

Testing of pipes and fitting shall be carried out in accordance with relevant Indian Standard and internationally approved standard. Pipes, fittings and expansion bellows shall be hydrostatically tested for 1.5 times the rated pressure.

The following test shall be carried out for pipelines:

(1) Pressure test
(2) Leakage test
(3) LP test for welding pipeline
(4) Welding beat check
(5) Dimensional Check
(6) Visual Inspection

14.1.5.5 Compressors and Blowers

Tests shall be carried out in accordance with the relevant international standard. All compressors and blowers shall be tested with their ancillaries to confirm design performance particularly in respect of flow and pressure. The test shall demonstrate that vibration and noise are within the specified limits and that the pressure relief valve operates correctly.

Air receiver shall be tested in accordance with the relevant section of B.S. 5169.

All pressure vessels shall be inspected and hydro water tightness tested. Test will be conducted with Job Motors at Compressors/Blowers manufactures place.

14.1.5.6 Process Plant Items

All process plant items shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction, and performance at the place desired by client.

14.1.5.7 Crane & Hoists

The cranes shall be completely assembled in the Contractor's or subcontractor's Works and shall be subjected to the tests as specified in IS 807/IS 3177 or relevant internationally approved standard. The Contractor shall provide the test weights.

Hoists and lifting equipment shall be assembled and tested at the place of manufacture in accordance with IS 3938.

Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G16 of ISO 1940/1 - 1986.

14.1.5.8 Sluice Gates

(a) Seat Clearance Check

With the gate fully closed, the clearance between seating faces when checked with the filler gauge, shall not exceed 0.1 mm.

(b) Movement Tests

Each gate shall be shop operated Manually/Electrically three times from the fully open position to the fully closed position and return to fully open, under no flow conditions to demonstrate that the assembly is workable.

(c) Leakage Tests

With the gate in closed position design pressure shall be applied for a period not lesser than 5 minutes to the unseating side of the sluice gate and the leakage shall not exceed the maximum leakage permissible as per IS 13349.

(d) Hydrostatic Tests

Finally a differential of one and a half times the design pressure shall be applied to the unseating side of the gate. Under these tests no part shall show any deflection of deformation.

14.1.5.9 Medium and Fine Screens

(a) All screens shall be checked for overall dimensions, assembly, and clearance between the bars / space between a rake and bar surface / aperture size and its material as well as painting works. Moreover, motion of rake/drum and wiper/self-cleaning arrangement shall also be tested at works.

(b) Conveyor shall be checked for dimensions and physical conditions, belt joint portion, travelling accuracy of belt, motors and its power consumption, performance of safety device.

(c) At least one screen of each type shall be tested for efficiency and operation by employing screenings. For the screen having depth of channel more than 3 metres, testing with reduced depth is acceptable.

14.1.5.10 Fine Bubble Diffusers

(a) Clean water Standard Oxygen Transfer Efficiency (SOTE) tests shall be performed for each different diffuser grid geometry/arrangement proposed in the design. These tests shall be performed by the diffuser Manufacturer at the Manufacturer's testing facility or an equivalent facility appropriately equipped with an adequately sized testing tank and other required appurtenances. The testing shall be performed in full compliance with the latest version of the applicable standard testing protocol. These tests shall be witnessed by Engineer per procedures set forth for witnessing elsewhere in this document.

(b) All diffusers including 5 % spares shall be thoroughly inspected by Contractor for physical damage to the membrane or any other part of the diffuser and results of the inspection shall be reported to Engineer.

Field test

The test will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.

Levelling tests:

1. Introduce clear water into each tank to the top of the diffuser elements.
2. Check the level of the diffusers to verify that all element horizontal surfaces are within 10 mm of a common horizontal plane and at the specified elevation.

Leakage and distribution of flow tests:

1. After successful completion of the levelling tests, raise the water level to 50mm above the manifold.
2. Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.
3. Repair any leaks in the elements holders, elements, pipes or the like.
4. Repeat the test until the installation is essentially void of air leaks.

14.1.5.11 Reinforced Cement Concrete Pipes

Testing

(1) All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.

(2) Contractor shall provide laboratory test /analysis results of cement and aggregate component and cement vs. aggregate vs. water mixing ratio and concrete mixing time and mixing method.

(3) During manufacture, tests on concrete shall be carried out as per IS:456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS:458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

(4) The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS:458 and tests in accordance with the methods described in IS:3597.

(1) Hydrostatic test
(2) Three edge bearing test
(3) Absorption test
(4) Dimension and colour of surface
(5) Damage

Sampling and Inspection

(1) In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

(2) The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS:458.

(3) Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every r-th pipe be selected till the requisite number is obtained, r being the integral part of N/n where N is the lot size and n is the sample size.

(4) All pipes selected shall be inspected for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

(5) The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

(6) A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

(7) The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS:458.

(8) All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

(9) In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

(10) All destructively tested samples shall be replaced to new.

14.1.5.12 Steel Cylinders Pipes and Specials

Testing

a) Welding beat check Remove all scale on the welding points and welding beat and its thickness shall be checked by the Engineer.

b) Penetration Test

A suitable penetrating liquid (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrating time, the excess penetrant, which remains on the surface is removed. Then a light coloured powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

c) Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

d) Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However,

when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS:3658 or other approved means.

e) The contractor has to submit QA/QC and methodology for welding works

f) Approval of welding rods

g) Welders qualification Test

14.1.5.13 Cast Iron / Ductile Iron Pipes

Mechanical Tests

Mechanical chemical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

Brinell hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

14.1.5.14 Chlorination system

(a) All items of plant shall be tested at manufacturer's works and test certificates shall be provided.

(b) All chlorine gas piping from chlorine drums to chlorinator shall be pressure tested with dry air/nitrogen to a pressure of 15 kg/sq.cm.

(c) The chlorine gas piping from the chlorinators up to injectors shall be pressure/vacuum tested with dry air/nitrogen to a pressure/vacuum equal to 1.5 times the maximum pressure/vacuum to be encountered during operation.

(d) The motive water piping shall be hydrostatically tested for a pressure of 1.5 times the operating pressure or the maximum pump discharge pressure at pump shut off whichever is higher.

(e) After the chlorine system has been completely tested as above leak tests shall be conducted admitting chlorine gas. Leakages if any shall be identified using ammonia stick. During this test all chlorine leak detectors shall be in place and all safety procedures shall be adhered to.

(f) Gas cylinder shall provide the pressure test certificate issued by authority and manufacture year.

(g) Chlorine gas detector sensors shall be tested, and results shall provide to the Engineer.

(h) Ventilation system :
The ventilation fans shall be tested at manufacturer's works to verify the design flow and pressure.

(i) Process Plant Items;
All process plant items shall be tested to ensure they meet the Employer's Requirements for inlet and outlet quality of workmanship, construction and system performance.

14.2 Mechanical equipment

All mechanical equipment shall be tested at site as following items in bellow,

(a) The test will be verified any damage/missing part, No. of equipment to be installed, material, location as specified in drawing, levelling, centreline, solid installation and condition of installation to be fit in levelling of pipeline and valves.

(b) Testing run will be conducted for verifying rotation direction, vibration, noise, and stability and any leakage, if possible.

(c) The test will be verified to check maintenance space and ease of equipment maintenance work.

(d) The testing shall be performed in full compliance with the latest version of the applicable standard testing protocol. These tests shall be witnessed by Engineer per procedures set forth for witnessing elsewhere in this document.

14.3 Tests at site

(a) In addition to the progressive supervision and inspection by Engineer, the Contractor shall offer for inspection to Engineer, the completely erected plant/part of Plant on which tests are to be carried out. After such inspection, each equipment/sub-system shall be tested by the Contractor in accordance with the applicable standards in the presence of Engineer. Such tests shall include but not be limited to the tests specified in following clauses.

(b) The Contractor shall possess during the entire working period the Electrical Contractor's licence of appropriate class from the concerned statutory authorities governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations. On completion of the installation or at intermediate stages, if required by the statutory authorities, the Contractor shall arrange for inspection and obtain the approval from the concerned statutory authorities. If any fees are to be paid to statutory authorities for testing, inspection and calibration shall be paid by the Contractor and shall be included in his erection and commissioning charges.

14.4 Pumps, piping and valves

(a) The erected pipe work shall be subjected to a hydraulic test at 1.5 times the maximum pressure or twice the working pressure whichever is higher to test the soundness of the joints. Provision of the necessary pumps, gauges, blank flanges, tappings etc. for carrying out these tests shall be included in the Contract. All gas piping shall be air tested to twice normal working pressure.

(b) Leakage tests shall be carried out on all erected pipework, pumps and valves immediately after erection and where possible before being built in.

(c) Operating tests shall be conducted on valves.

(d) The pump set shall be tested for satisfactory operation. The vibration and noise level shall be checked to be within the specified limits.

14.5 Motors

Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.

14.6 Cranes

The crane and lifting tackle shall be tested to 125 % of the safe working load. The Contractor shall arrange the test load. The contractor shall also arrange for the appropriate certificates from the concerned authorities before regular use of the cranes and other lifting equipment.

14.7 Screens

After erection, all screens screen shall be tested for smooth operation and capability to handle typical wastewater solids including stringy materials. Clearance between the dead plate and tines shall be checked as applicable.

14.8 Gates

(a) Leakage test shall be performed by the Contractor after installation of all Gates.

(b) Under the design seating head and unseating head the leakage shall not exceed the limit specified in IS:13349, for shop testing.

14.9 Reinforced Cement Concrete Pipes

(a) After laying and jointing of RCC pipes is completed the pipe line shall be washing out with sufficient water and be tested at work site as per the Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

(b) After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour.

(c) The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 litre/ hour/100 linear metres/ 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

(d) In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

14.10 Steel Cylinder Pipes and Specials

(a) After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be washing out with sufficient water and be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

(b) Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rewelded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

(c) Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

(d) Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

(e) A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

(f) If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and rewelded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

(g) The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

14.11 Cast Iron, Ductile Iron Pipes and Fittings

(a) After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test after washing the pipe line out with sufficient water.

Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until at least two days have elapsed.

(b) Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge shall be applied by means of a pump connected to the pipe as directed by the Engineer.

(c) The duration of test shall not be less than 5 minutes. The exposed joints hall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

(d) After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm^3 /h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{3.3}$$

Where,

q_L = The allowable leakage in cm^3/hr

N = Number of joints in the length of the pipeline

D = Diameter in mm, and

P = The average test pressure during the leakage test in Kg/cm^2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

(e) Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

(f) After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer’s Requirements specified elsewhere.

14.12 Manufacturer's Works Acceptance Tests on Electrical Equipment

The following equipment / items shall be subjected to inspection, routine /acceptance tests as per latest edition of relevant Indian / International standards in the presence of Employer/ his Engineer.

(a) 11/3.3 kV Transformers
(b) 11/0.433 kV Transformers
(c) 11 kV Metal enclosed switchboards & Switchgears.
(d) 3.3 kV Metal enclosed switchboards
(e) 415 V metal enclosed switchgears (PCC) /MCC
(f) Power capacitor and control panel
(g) Diesel Standby Generator with AMF Control Panel
(h) Battery, battery charger and DC Distribution Board
(i) Variable Frequency Drives
(j) Non Segregated Bus Duct
(k) Power & control cables
(l) Cable carrier system
(m) Lighting system
(n) Earthing and lightning protection systems

Copies of test Certificates for the type tests and Special tests not later than 5 years conducted as per relevant Indian / International Standards for all the equipment /items of above shall be furnished for the perusal of Employer / his Engineer. If type tests and special tests have not been conducted on any of these items, the same shall be carried out in the presence of owner/ Engineer at no extra cost.

14.13 Manufacturer's Works Acceptance Tests on Instrumentation, PLC, SCADA and Associated Equipment

A. Instrumentation:

Inspection, Testing and Setting to Work:
General

Each item of plant shall be subjected to the manufacturer's own tests which shall be certified.
Each instrument, shall be subject to inspection and testing at the place and country where the equipment has been manufactured at the manufacturer's factory works. This shall include all instrumentation, analytical instruments.
The Contractor shall be responsible for the provision of all necessary test equipment. The Contractor shall demonstrate to the Engineer, the correct operation of any item of plant and the Engineer may witness any test. Tests which, in the opinion of the Engineer, were failed or not performed correctly shall be repeated.

Calibration tests for field instruments and analytical instruments should be conducted on site after installation and the same should be witnessed by the Engineer.

Before any test is made, the Contractor shall submit to the Engineer a full list of test equipment & test procedures (method statements) to be used. Each item of test equipment shall have a standard of accuracy better than that stated by the manufacturer of the item to be tested. The Contractor shall provide evidence of the condition and performance of any item of test equipment, in the form of test certificates issued by an appropriate authority independent of the Contractor and manufacturer, or as otherwise directed by the Engineer. Test equipment shall be checked frequently during the period of the tests.

The Contractor's staff responsible for supervising and carrying out tests shall be fully conversant with the various items of equipment of other manufacturers and if necessary the Contractor shall arrange for his personnel to attend suitable training courses on his own expense.

Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection or testing of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

Preliminary Inspection and Testing at the Place of Manufacture

Field-mounted instruments

After the successful completion of the manufacturer's own inspection and testing of instruments supplied under the Contract, similar tests shall be carried out in the presence of the Engineer and the Contractor at the same facility where the instrument has been manufactured. Complete functional check of the instrument shall be carried out in the presence of the engineer and his representative. Such tests shall include a demonstration that an increase or decrease of the measured value at several points over the full range of the instrument produces a corresponding increase or decrease in the instrument output signal. These tests shall include checks on the specified accuracy of the instrument at all points. Calibration check of the instrument shall be carried out.

Instrument panels, enclosures and mounting boards

The manufacturer shall not present instrument panels, enclosures and mounting boards (assemblies) for inspection and testing until the manufacturer's own tests and inspection has been completed. A preliminary inspection and test of these assemblies may then be witnessed by the Engineer. The Contractor shall give not less than 7 days' Prior notice in writing that he has completed.

His tests and inspection and is ready for the witnessed tests and inspection. Where this notice period is different in the Conditions of Contract this shall take precedent.

The witnessed inspection and testing shall include the following:

a. A visual inspection of the panel assembly to show that the design, construction and finish are satisfactory and in accordance with the Specification;
b. A check that equipment is securely mounted, accessible for removal or calibration without damage to or undue disturbance of other components, wiring or piping;
c. That all engraving and labels are correctly positioned, fixed and designated in accordance with the Specification;
d. Panel power-distribution circuits have the correct breaker/fuse rating coordination and designation;
e. Power-isolation facilities meet the Specification;
f. The main incoming supply voltage, frequency and/or pneumatic supply pressure is within the required limits, these being checked at the beginning and end of the test and the results recorded on test certificates;
g. The output of all power supply units again at the beginning and end of the testing with results being recorded;
h. The power supply voltage or air pressure of all component instruments of the assembly(s), these voltages/pressures being recorded on the test certificate;
i. The insulation resistance of all circuits except sensitive electronic equipment which is liable to damage by application of the test voltage, such circuits being disconnected before making the insulation resistance tests and these tests being carried out in accordance with IEE Wiring Regulations;
j. That the clean earth bar is isolated from main frame of the panel.

Internal lighting and anti-condensation heaters and associated thermostats, isolators, limit switches and wiring shall be checked for compliance with the Specification.

Spare capacity within the panel(s) shall be checked to see that it complies with the Specification. This shall include future equipment space, spare terminals, space in wiring trunkings and provision for additional cable entry.

Functional Testing at the Place of Manufacture where the equipment/instrument has been manufactured

General requirements

Once the preliminary inspection and testing is complete to the satisfaction of the Engineer, functional testing shall commence. The purpose of the functional tests are to demonstrate that instrument panels enclosures and mounting boards (assemblies) conform with requirements of the Specification.

Not less than 30 days before the commencement of functional tests, the Contractor shall submit to the Engineer, for approval, two copies of comprehensive test procedural documents detailing each test to be carried out. The document shall include results forms on which the results of each test will be entered. The forms shall include spaces for numerical values, where necessary, and witness signatures.

All applicable drawings and data shall be provided at the place of inspection by the Contractor.
The Contractor shall provide all test instruments and equipment necessary to test the assemblies in their entirety.

The following is a typical list of the equipment required:

- Switch boxes;
- Indicator light boxes;
- Analogue signal sources;
- Dummy loads;
- Meters;
- Simulators;
- Desk-top computers;
- Programmers for PLC SCADA or outstations;
- Insulation test equipment

B. Control & Automation system-Programmable Logic Controller (PLC) and SCADA systems

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.
The tests shall be carried out on the fully assembled control panel containing the PLC, RTU, RIO and SCADA system and its ancillaries and associated equipment in order to demonstrate correct functional operation of the hardware and software systems. No part testing of the system shall be acceptable. PLC and SCADA system in its totality as per approved functional design specifications shall be tested as one unit only. Contractor shall take note of the same.

Factory Acceptance Test (FAT)

The Contractor shall conduct a full programme of tests of the PLC & SCADA system at the Contractor's testing facility in the presence of the Engineer to verify that all features of the system have been provided, are operating correctly and are in full compliance with the Specification. FAT shall include PLC based SCADA system for STP and PLC based control system with panel mounted HMI for ISPS(s) with wireless communication system for the all of the above. Unless otherwise specified or agreed by the Engineer, the entire PLC & SCADA system shall be assembled and tested together as an integrated system, including all master station equipment, all operators' consoles, all outstations and telemetry equipment all instrumentation panels and uninterruptible power supplies included in this Specification. The scheduled date for the factory acceptance test shall be as agreed by the Contractor and the Engineer at least four weeks before the test. FAT shall be conducted with a hardwired simulation panel connected to the PLC based SCADA system. Contractor shall note the importance of the requirement. No software based simulation testing shall be accepted or allowed.

Not less than one month before the scheduled factory acceptance test, the Contractor shall submit to the Engineer for approval two copies of a comprehensive manual detailing each test to be conducted. The manual shall include a results form on which the results of each test will be entered, including spaces for numerical values where appropriate and witness signatures.

Not less than 7 days before the scheduled factory acceptance test, the Contractor shall give written notification to the Engineer that a complete dry-run of the factory acceptance test has been performed successfully and that, in the opinion of the Contractor, the system exhibits stable operation and is ready for the formal factory acceptance test.

The factory acceptance test will be considered successfully completed only when the system has successfully passed all factory tests. The system shall not be delivered to Site until the successful completion of the factory acceptance test is certified by the Engineer or unless otherwise approved by the Engineer. Delay in the delivery of the system due to failure of the factory acceptance test shall not constitute an unavoidable delay. If the system fails the factory acceptance test, the test shall be extended or rescheduled at the discretion of the Engineer.

All hardware to be used in the testing of the system shall have passed an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.

After successful completion of the factory acceptance test, no software changes shall be made to the system without written authorisation by the Engineer. Any changes to the system which effect the system software documentation, such as input scale modifications or changes to the control logic, shall be

entered into the system documentation before delivery of the system to Site. All instruments under IC&A scope has to be tested for 100% qty.

Factory Acceptance Test Procedures

General

The scope of the tests shall include the proving of every aspect of hardware and software operation and functions as detailed below.

Hardware tests

(a) Verify the correct inventory of hardware including cables and printed circuit boards;
(b) Demonstrate that all spare-memory, disk-capacity and system-expansion requirements have been met;
(c) Demonstrate all hardware and software diagnostics;
(d) Verify all power supply voltages are within tolerance;
(e) Verify proper earth connections and isolation of instrumentation earth for all equipment;
(f) Demonstrate operation of test simulation and indication equipment and its Suitability for adequate functional testing of all system functions.

Software tests

(a) Demonstrate the editing of all system parameters including set-points, timers and the like;
(b) Demonstrate system configuration capabilities including the addition and deletion of input and output points, outstations, and all data base parameters;
(c) Demonstrate the addition, deletion and modification of mimic displays and report formats;

Functional tests

The functional tests shall verify proper operation of every specified system function as an integrated system. These tests shall be conducted in conjunction with functional tests of instrumentation and control panels as specified elsewhere. All failures or discrepancies found shall be documented in the test manual. Following a failure of any functional test, should software or hardware modifications be required it shall be the decision of the Engineer whether the factory acceptance test is to continue, re-start or be aborted. If testing is allowed to continue, any changes which are required shall be described in a system modification document, signed by both Contractor and Engineer and be incorporated into the final factory acceptance test documentation. The failed test shall be re-conducted and the Engineer may require the retest of functions which may be affected by the modification.

The functional tests shall include, as a minimum, the following:

(a) Demonstration that the system meets the requirements of the Specification for response time and speed of screen update;

(b) Verification of the accuracy of all analogue input points in the system. The procedure shall include applying the appropriate signal to each analogue input at a minimum of three points within the range of the input, checking for expected numerical results, and verifying appropriate update of related mimic displays. Proper sensing and action by the system to high and low out-of-range inputs shall also be verified;

(c) Verification of the proper logic sense, pulse accumulation and rate computation where appropriate, of all digital inputs and verifying appropriate update of related mimic displays;

(e) Verification of all control and sequencing operations and proper operation of all digital and analogue outputs. The procedure shall include simulation of all related process variables for both normal and abnormal conditions, including instrument and component failure, and demonstration of fail-safe response of the system. System outputs shall be indicated with appropriate lamps and indicators;

(f) Simulation of outstation communications errors and failures and demonstration of error detection and handling, failure detection and handling, and appropriate changes to control actions as designed and specified;

(g) Verification of fault detection and diagnostics by inducing a sufficient variety of fault conditions in the system to ensure that detection processes and fail-safe operation are adequately tested;

(h) Demonstration of proper operation of all mimic displays, help pages, reports, operator procedures and historical data accumulation;

(j) Demonstration of proper operation of all outstations following a simulated master station central processor failure;

(k) Demonstration of proper operation of all equipment during both a system wide or isolated power failure, and following power restoration. The procedure shall include the demonstration of battery backup of both master station and outstation for the full length of time specified, and proper operation of power fail, low voltage warning and all associated alarms.

Reliability test

After successful completion of the functional tests a 48-hour continuous run of the system shall be performed. The test shall be passed if no system function is lost or no hardware or software failure occurs. Hardware failure is defined for this test as the loss of a major component such as the computer, an outstation, a VDU or a peripheral device. Non-repetitive mechanical failures of loggers, push-buttons and the like are excluded.

During this test, the system shall be exercised with simulated inputs and conditions in a manner which approximates the on-site operational environment. Unstructured testing by the Engineer shall be included during this test. Upon any system failure during this period, it shall be the decision of the Engineer whether the reliability test is to continue or be aborted. If testing is allowed to continue any changes to the system which are required shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final factory acceptance test documentation.

Factory acceptance test documentation

As a minimum, the following information shall be included in the factory Acceptance test manual for each test:

- Test identification number;
- Test name and description;
- List of all equipment to be tested including any special test equipment required;
- Description of the test procedure broken down into logical steps;
- Description of the expected system response verifying the completion of each logical step;
- Space for recording the results of the test and the time and date of the test;
- Space for signatures of the Contractor and the Engineer.

In addition, the Contractor shall provide a method for recording and tracing all problems, discrepancies, queries and suggestions regarding the system and software, and for formalised control of any modifications to the system.

Pre-commissioning tests

The Contractor shall perform pre-commissioning, or preliminary, testing of the SCADA system in accordance with that specified for instrumentation. The purpose of pre-commissioning tests is to confirm readiness of the system for commissioning.

The scope of pre-commissioning tests shall be generally as specified for factory acceptance tests but real field inputs and final control elements shall be used wherever practical to provide inputs to the system and to confirm proper outputs.

Where this is impractical, simulation signals shall be injected as near as possible to their ultimate sources so as to include in the tests as much of the cabling system as possible.

Each process system shall be set to work under manual control and the system tested to confirm proper operation. After proper operation of manual control mode has to be verified, tests of automatic controls of each process system shall be conducted wherever practical.

Commissioning

Site Acceptance Tests (SAT)

The Contractor shall submit all relevant draft operating manuals for the PLC & SCADA System to the Engineer for approval prior to commissioning tests.

Any faults or failures of the system detected during the previous tests shall be noted and corrected to the satisfaction of the Engineer before commissioning is allowed to commence.
As part of commissioning, the PLC & SCADA system shall be tested for availability for a continuous period of 90 days wherein the SAT will be conducted for the complete plant, process, mechanical, electrical and ICA equipment. During this period, the system will perform the normal functions according to the procedures described in the SAT documentation approved by the Engineer. During SAT, the complete plant shall be tested in manual mode of operation, semi auto mode of operation and auto mode of operation to certify each and every equipment individual functioning and as a complete system to satisfy plant functional guarantees.

The system shall have passed the SAT if all major components have been free from fault or failure and exhibit full error-free functionality for 100 % of the total duration of the test, unless otherwise agreed by the Engineer. Major components include all master station equipment, outstations, communications facilities and instrument panel components, excluding push-buttons, switches and lamps and any equipment not supplied by the Contractor.

During SAT, no modifications to the system shall be made by the Contractor without the written approval of the Engineer. Erroneous functioning which requires software modifications or re-configuration to correct, other than set-point or parameter changes, shall constitute a failure of the availability test. Any changes to the system which are required and approved shall be described in a system-modification

document, signed by both Contractor and Engineer and the document shall be incorporated into the final test documentation. The test shall be restarted after corrections have been made.

14.14 Manufacturer's Works Acceptance Tests on Uninterruptible Power Supplies

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following:

(1) Change-over from full load with mains present to full load on battery supply
(2) Carry out a discharge test on the system at full load and for the specified duty bridging time period.
(3) Carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.

14.15 Inspection at Site

During erection of the Plant the Engineer will inspect the installation from time to time in the presence of the Contractor's Supervisor to establish conformity with the requirements of the Specification. Any deviations found shall be corrected as instructed by the Engineer.

14.16 Plant protection on Site

Factory finished plant shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

14.17 Erection staff

The Contractor shall provide at least two approved senior English speaking working erectors to supervise the erection of all Plant in the Contract and in each case to act as the Contractor's Representative as set out in Clause 13 of the general conditions of contract.
In the case of a foreign firm based overseas the Contractor's Representative shall be thoroughly conversant with the manufacturer's Plant and equipment, and its erection and shall be an expatriate.
The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering, with such skilled, semi-skilled and unskilled labor as are necessary to ensure completion of

the various sections of the Contract in the time required. The Contractor shall not remove any supervisory staff or labor from the site without the prior approval of the Engineer.

The Engineer will give the Contractor at least one month's notice in writing of the date on which the erection staff will be required on site, and the Contractor shall confirm the date of arrival in writing to the Engineer. The Contractor shall make all the necessary arrangements to ensure that sufficient plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection.

It shall be the responsibility of the contractor to obtain necessary License/ Authorization/ Permit for work from the Licensing Boards of the Locality/ State where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognized by the Licensing Board of the Locality/State where the work is to be carried out.

14.18 Erection and Building-in

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

It will be the Contractor's responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The Contractor shall carry out the complete erection of all plant, including the provision of all necessary skilled and unskilled labor, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and satisfactory erection of the Plant.

The Contractor shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the employer. In case the cleaning is not up to the employer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the employer in this regard will be to the Contractor's account.

Erectors

The Contractor's employees shall include skilled erection staff in sufficient number, who shall arrive on the site on or before the respective dates set out in the approved work programmed and prior to delivery of any item of Plant to the Site. The Engineer will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the site.

Contractor's Equipment, materials and appurtenances

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of Plant and to handle any emergencies such as may normally be expected in work of this character.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the Contractor, till the installation is taken over by Employer shall be made good by the Contractor to the satisfaction of Engineer.

Workmanship

Plant shall be erected in a neat and workmanlike manner on the foundation and at the locations and elevations shown on the approved drawings and other Engineering documents. Unless otherwise directed by the Engineer the Contractor shall adhere strictly to the aforesaid drawings and no departures there from will be permitted.

All plant shall be correctly aligned, leveled and adjusted for satisfactory operation and shall be installed so that the proper and satisfactory connection can be made readily between the various units and pipe work and equipment installed under the Contract. The mounting arrangements for pumpsets and blowers shall be such that the alignment offset between motors and the driven equipment shall be well within 0.1 mm.

Building-in

Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other contractors. Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of plant are to be installed, and shall bring any deviations from the required positions, lined or dimensions to the notice of the Engineer and shall take such measures as are necessary for their correction.

The Contractor shall take particular care for the correct positioning and alignment of all puddle pipes which are required through concrete structures prior to, and during the pouring of concrete.

The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc., required for fixing electric wires and conduits, small pipe work and all other apparatus.

The Contractor shall align all equipment and holding down bolts and shall inform the Engineer before proceeding with grouting-in the item or item concerned. The Contractor shall ensure that all equipment is securely held and remain in correct alignment before, during and after grouting-in.
The Contractor shall properly bed in cement grout each item of plant or its supporting base resting on foundations, and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid

anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundations, without shrinkage or cracking.

During erection of the Plant the Employer will inspect the installation from time to time in the presence of the Contractor's Site representative to establish conformity with the requirements of the Specification. Any deviations and deficiencies found or evidence of unsatisfactory workmanship shall be corrected as instructed by the Employer.

All plant shall be installed in accordance with the recommendations or instructions of the manufacturer, for the particular application. Each mounting position shall be chosen to give correct operation of the equipment, ease of operation, access for maintenance and servicing and freedom from any condition which could have adverse effects.

Precautions

The approval by the Engineer of the Contractor's proposals for rigging and hoisting of any item of plant into its final position shall not relieve the Contractor from his responsibility for avoiding damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Engineer.

No plant or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be transferred to floor beams and girders of steel or concrete. If it is required to reduce bending stresses or deflection, the beam and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subject to the prior approval of the Engineer.

14.19 Civil Inspection (Water Leakage Test)

14.19.1 Tanks and basins

Refer to Part 10B – Particular Civil and Structural Works Requirements of the Bid Document

14.19.2 Field Control Inspection

Contractor shall be conduct periodic field control inspection to prevent any field accident. The Engineer shall joint field inspect or conduct unannounced inspections.

14.19.3 Inspection after Erection

After the erection of any item of Plant and its associated equipment has been completed, it shall be offered to the Engineer for inspection in its static state prior to commissioning the item.

Completion of erection and procedure prior to setting to work.

The mechanical completion of plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below:

All rotary, static, structural equipment, piping, electrical/instrumentation and other equipment under the scope of the Contract have been erected, installed and grouted and are as per the specifications.
All systems have been washed/flushed/drained/boxed up where necessary.

All system testing including pressure, vacuum and nondestructive tests, no load tests and such other tests are completed with safety valves/relief valves set to operating conditions installed in position.

All panels, local control desks erected with power/control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

Prior to pre-commissioning checks, the Contractor shall erect the entire Plant and ensure readiness of civil works to the satisfaction of Employer, so that the Works are physically ready to undergo pre-commissioning checks. Pre-commissioning checks will include checks like no-load running of machinery, checks on instruments and electrical including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo pre-commissioning checks.

The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Employer

(a) All shop inspection records compiled and bound in 4 (four) copies.
(b) All erection and commissioning procedures duly approved.
(c) All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Employer of such completion of section/units/systems and readiness for inspection for acceptance of mechanical completion of erection. The Employer/ Engineer shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Employer will inform the Contractor a list of deficiencies for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

14.20 Site Acceptance Test Document

Fifty six (56) days prior to commencement of Tests on Completion the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Engineer.

The SAT shall categorise tests as follows:

a) Dry tests

Dry tests are those tests carried out without process fluid being present.

b) Wet tests which can be further sub-divided into

(1) Hydraulic tests

Hydraulic wet tests are those tests carried out with potable water in order to prove the hydraulic capability of the Works.

(2) Process tests /System tests

Process wet tests are those tests carried out with raw Sewage as the feed stock to prove the process capability of the Works. Manual mode, semi auto mode, auto mode operation of the individual units and as combined plant operation shall be tested.

The Contractor shall make his own arrangements for water supply, chemical, electric power, fuel, instrument and labour during hydraulic wet tests.

It shall be assumed that the co-operation of other contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

14.21 Tests on Completion

14.21.1 General

Prior to the commencement of Tests on Completion the Contractor shall submit for approval the following:

(1) Site Acceptance Test Documents
(2) As-Built Drawings
(3) Operation and Maintenance Manuals
(4) Site test results / data sheet and photo

Tests on Completion shall not be commenced until the aforementioned documents are approved.

The initial charges of oil, grease, electrolyte, generator fuel / oil, chemical, disposal of cake, etc. necessary for Tests on Completion shall be provided by the Contractor. Raw Sewage and electricity required for Tests on Completion will be provided by the Employer free of charge. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested. In the event that raw sewage/influent wastewater is not available at the plant, the Contractor shall defer testing until such time as sewage becomes available for treatment as described elsewhere in these Bid Documents. The Contractor shall provide adequate notice (this notice period shall be determined by the normal lead time for locally purchased chemicals plus at least 28 days) of his chemical requirements prior to commencement of the Tests on Completion involving their use.

The cost of chemicals used for the Tests on Completion shall be met by the Contractor.

In the event of any discrepancy in the design/testing standard provided for a specific equipment, then the latest edition of the respective standard shall prevail over whatever is mentioned in the tender specification.

The inspection and tests procedure which will be carried out are provided under the general conditions of contract and shall also consist of the following:

a) Manual Commissioning Tests (Clause i)

Manual Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete systems as are required by the Engineer in order to demonstrate that the Plant as a whole is ready to undergo the Manual Operation Tests (Clause 3.11) and that these will take place with a minimum of interruption.

The Manual Commissioning Tests shall demonstrate not only the items of Plant under normal operation, but also their response to abnormal and emergency conditions.
The Engineer will notify to the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the Specification.

Leakage tests at 1.5 maximum working pressure shall be carried out on all erected pipe work prior to the Manual Commissioning Tests.

Pump curves shall be available for the Manual Commissioning Tests and all instruments essential for the tests shall have been calibrated.

b) Manual Operation Tests (Clause ii)

When the Manual Commissioning Tests have been completed so that the items of Plant have been demonstrated to the satisfaction of the Employer Representative, the Contractor shall commence the Manual Operation Tests.

These tests shall demonstrate the correct operation of the whole Plant whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required both for the maintenance of safety and for the normal mode of operation of the Plant.

The Plant will be required to demonstrate satisfactory operation at all design flow rates.

The tests shall be of seven consecutive days' duration; if the supply of water should fail or other matters interfere outside the Contractor's control, the tests may be of such number of broken days as the Engineer considers is the equivalent.

The exact date of commencement shall be subject to the approval of the Engineer and shall be dependent on the following conditions having been met

(1) All relevant items of Plant in approved working order
(2) All items of Plant correctly identified with labels

c) Automatic Commissioning Tests (Clause iii)

The Automatic Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete system as are required by the Engineer in order to demonstrate that the Plant as a whole is ready to undergo the Tests of Completion (Clause 3.13) and that these will take place with a minimum of interruption.

At least one week before the commencement of these tests, the Engineer will notify the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the specification.

The Tests on Completion (Clause 3.13) as provided under the general conditions of contract-clause 37 shall not be carried out until the completion of the above tests.

(1) All pipe work shall be hydrostatically tested at site to a pressure equal to 1.5 times the maximum working pressure likely to be encountered in the system.

(2) The Contractor shall carry out all tests on the Plant and shall supply four copies of all test results to the Engineer.

(3) All tests shall be to the approval of the Engineer who may require them to be repeated, prolonged or modified as may be necessary to ensure that any or all items of Plant conform to the Contract.

(4) The Engineer shall be permitted to inspect all Plant which is undergoing tests and may himself conduct tests.

Where it is necessary for the Engineer to make arrangements for the supply of water, chemicals, power, etc., for any testing, the Contractor shall not commence the tests until after these arrangements have been made on or after a date agreed by the Engineer and the Contractor shall make no claim for delay to such testing on this account except as provided for under Clauses 44 of the General Conditions of contract.

If any item of plant fails during or after testing to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and re-tested and re-inspected as required by the Engineer.

Vibration/noise level tests shall be carried out at site which will form basis for acceptance of the equipment. If the Contractor is not in a position to meet the requirements given below as per ISO 10816 – 1995, the equipment may either be rejected or the Contractor shall carry out all necessary modifications to keep vibrations within the acceptable limits specified.

Equipment	Noise Level (dBA at 1.86 m from equipment)	Velocity of vibration (mm/sec)
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	85	1.12
All rotating equipment not having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	85	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	85	2.8
All equipment having reciprocating parts viz. compressors, dosing pumps sampling pumps	85	-

The Contractor shall have a minimum of three commissioning engineers, one for process and plant and the other for mechanical/electrical/instrumentation works on site during all tests in order to both demonstrate the Plant and to correct any faults which may occur.

14.22 Dry Test Requirements

As a minimum requirement the following dry tests shall be carried out as a general requirement:

(1) A general inspection to check for correct assembly and quality of workmanship
(2) A check on the presence of lubricant, cooling medium, electrolyte, etc.
(3) A check on adequacy and security of Plant fixing arrangements.
(4) A general check to ensure that all covers, access ladders, water proofing, guard railings etc are in place.
(5) A check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside.

a) Civil and Building Works

As a minimum requirement the following dry tests shall be carried out on the civil engineering and building works:

- Check for the presence of foreign bodies in pipe work and structures.

b) Mechanical Works

As a minimum requirement the following dry tests shall be carried out on the mechanical systems:

- Carry out preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of Plant.

c) Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems:

(1) Check phasing and polarity.
(2) Carry out point to point check on all cables.
(3) Check on security of cable terminations.
(4) Check on completeness and adequacy of earthing systems.
(5) Check setting on protection relays, sizes of fuses and motor overload settings.
(6) Carry out checks on cabling systems in accordance with the requirements of the relevant standards.
(7) Check operation of main circuit breakers by secondary injection methods.
(8) Check rotational direction of Plant.
(9) Check instrument loop integrity, functionality and calibration.
(10) Check operation of standby generator installation and mains / generator changeover procedures; a 4 hour load test (using the normal load of the Works) shall be carried out on the generator when the load is available.

(11) Check plant functionality.
(12) Check functionality of HMI and its power supply.

14.23 Process Plant Item / Equipment

All process plant items / equipment shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction and performance.

14.24 Hydraulic Wet Test Requirements

Hydraulic wet tests shall be carried out on completion of dry tests.

Clear Water shall be used for hydraulic wet tests. The purpose of the tests is to prove the hydraulic performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to ensure a sufficient supply of water to carry out these tests the Contractor shall provide all required facilities, including but not limited to any temporary facilities that may be required for storage and recycle of Clear Water or facilities for the disposal of the water off Site in an approved manner.

The following tests inter alia shall be carried out:

(1) Pressure testing of all piped systems lay direct in ground in accordance with the relevant standards.
(2) Fill all structures and check for leaks.
(3) Filling of all storage vessels to check for leaks and distortion.
(4) Running of all pumped systems in order to check for.
i) Correct functionality.
ii) Absence of leaks.
iii) Correct running temperatures.
iv) Smoothness of running and the absence of undue vibration or stress.
v) Check drive running currents.
(5) Carry out calibration of instruments where appropriate.
(6) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
(7) Demonstrate correct functionality of electrical, control and instrumentation systems.

The Contractor shall simulate the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops etc.

During these tests a check on the performance of Plant shall be made to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

14.25 Safety Audit

After satisfactory completion of hydraulic wet tests and prior to introduction of process fluid to the plant a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of Plant. The safety audit shall be documented. The safety audit document shall be approved by the Engineer prior to commencement of Plant commissioning.

14.26 Process Wet Tests (with Raw Sewage)

On approval by the Engineer the Contractor shall carry out process wet tests.

Raw Sewage shall be used as the main feed stock for process wet tests. These tests shall be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less than 48 hours. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested.

The Contractor shall provide all required facilities for the disposal off Site in an approved manner.

The following tests inter alia shall be carried out:

(1) Check for leaks on vessels, structures, pumps and pipe work.
(2) Running of all pumped systems in order to check for.
- ✓ Correct functionality.
- ✓ Absence of leaks.
- ✓ Correct running temperatures.
- ✓ Smoothness of running and the absence of undue vibration or stress.
- ✓ Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests.

(3) Carry out calibration of instruments.
(4) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
(5) Demonstrate correct functionality of electrical, control and instrumentation systems not checked during dry or hydraulic wet tests or which may have changed as a result of the different operating conditions now prevailing.

On completion of the tests on the various parts of the works the Contractor shall run the plant as a whole in order to demonstrate the full functionality and performance of the Works at various throughput rates for a continuous period of not less than 30 days.

During the various process tests the Contractor shall perform sampling and analysis of all the process streams (locations) and parameters listed in the "Sampling/Analysis Locations and Frequencies" table provided in the "Tests after Completion" Section below. The frequencies listed in this table shall be followed for the Tests after Completion. However, for the Process Wet Tests performed as part of the Tests on Completion, the sampling frequency for all locations and all parameters shall not be less than once every hour. The Contractor shall demonstrate to the Engineer that the Works is functioning in accordance with the Employer's Requirements. Each sample shall comprise two 1 litre (minimum) quantities and shall be labelled to identify the contents, where taken and time and date. The flow recorded at the time of sampling shall also be indicated in the log book or record. One sample shall be used by the Contractor for his analysis; the other shall be handed over to the Engineer.

The Engineer reserves the right to take additional samples and to carry out his own tests or to check the samples taken by the Contractor.

The Engineer shall be given reasonable access to the premises where analysis is taking place in order to check on working practices and the procedures being adopted.

14.27 Effluent Quality Criteria for Passing the Tests On Completion

The Works shall be considered to have achieved the required effluent quality standards for passing Tests on Completion if all samples taken during a 30 day continuous operational period comply with the criteria set down for passing the Tests after Completion. This includes criteria relating to the reliability of the plant.

The Effluent quality Tests on Completion shall not be commenced until all tests associated with the civil/building, electrical and mechanical works and individual process tests have been completed to the satisfaction of the Engineer.

14.28 Co-operation with other Contractors in the Execution of their Tests

The Contractor shall, where required, assist other contractors in carrying out their tests on completion and or tests after completion.

Where this assistance does not constitute part of the Contractors own work associated with Tests on Completion or Tests after Completion the Contractor shall be reimbursed at the rates approved by the Engineer.

14.29 Tests After Completion

General

On successful completion of "Test on Completion" the Contractor shall carry out over a period of time not exceeding six months two separate 30 days operational tests. These tests shall be used to prove the operation of the Works at varying flows and with varying raw Sewage quality. During these tests Effluent produced by the Works will be entering the disposal system. These tests after completion shall be undertaken in accordance with Clause 60 of the Special Conditions of Contract Clause 11 of the General Conditions of Contract.

The timing of the tests shall be determined by the Employer who shall give notice to the Contractor in accordance with Sub-clause 60.1 of the Special Conditions of Contract. The total time for carrying out the tests shall not be less than six calendar months. One of the tests for each part shall be carried out in a period of high raw Sewage BOD and suspended solids.

On commencement of each 30-Days test the Employer shall allocate a continuous period of not greater than 60 days to complete the test. Any failure to perform during the 60 days period shall restart the '30 day clock'. If the part of the Works fails to pass the test in the 60 days period the test shall be deemed as a failure and the Contractor shall carry out any necessary remedial work to the satisfaction of the Engineer before the Contractor restarts the test.

During the tests the Contractor shall take samples to demonstrate that the part of the Works is performing in accordance with the Employer's Requirements. The procedure for taking the samples shall follow the pattern adopted for Test on Completion. Samples shall be taken at locations and intervals detailed below. The results of the Tests after Completion shall be compared and evaluated by the Employer and Contractor.

The Contractor will not be held responsible for interruptions to the sewage treatment process as a result of Grid power failures (unless as a result of a Plant failure) interruptions in the raw Sewage supply etc. which are out of his control. However, the Contractor shall be required to demonstrate that the Works can cope with these inevitable interruptions in an orderly fashion and recover to a normal operational state with the minimum of manual intervention.

All consumables except power needed for operation of the Works shall be provided by the Contractor.

The Contractor shall provide all facilities and equipment not supplied under the contract and which are deemed necessary for the Contractor to carry out and monitor the Tests after Completion.

Sampling and Analysis

Sampling and analysis shall be performed to measure the parameters indicated in the table below, at the locations and frequencies indicated in the table. In case of multiple units (such as multiple aeration basins or clarifiers), the indicated sampling and analyses shall be performed for each individual module.

Sampling/Analysis Locations and Frequencies

Sample Location and Parameters to be Measured	Frequency	Sampling Method
Plant Effluent (outlet of chlorine contact tank): All parameters specified under the "Effluent Quality Requirements" sub-section of Volume 2, Section 7, Part 5.	Daily	Flow-weighted 24-hour composite
Raw Sewage Influent, Plant Effluent, Primary Sludge, MLR, RAS, WAS, Influent, Plant Recycles: Flow	Continuous	Continuous instantaneous flow from recorder
Raw Sewage Influent, Primary Effluent, and Secondary Effluent: TSS, VSS, Temperature, pH	Daily	Flow-weighted 24-hour composite
Raw Sewage Influent, Primary Effluent, and Secondary Effluent: BOD, COD, TKN, Ammonia-N, Nitrite-N, Nitrate-N, Alkalinity, Total Phosphorus, Soluble Phosphorus	3 times per week	Flow-weighted 24-hour composite
Aeration Basins: MLSS, MLVSS, Temperature, SVI	Daily	Grab
Aeration Basin Zone Profiles (Aerobic, Anoxic, De-Aeration): Ammonia-N, Nitrite-N, Nitrate-N, pH, Soluble Phosphorus, VFAs, RBCOD	3 times per week	Grab
PSL, RAS, WAS: TSS, VSS	Daily	Grab
Chemicals/Scum/Screenings/Grit: Specific weight, volume, weight, Chemical consumption	3 times per week	Grab

All costs associated with the taking and analysis of samples shall be met by the Contractor.

The analysis shall be carried out by certified laboratory (Karnataka State Pollution Control Board/Central Pollution Control Board) approved by the Engineer, and shall be performed in strict compliance with appropriate analytical methods published in Indian Standards, or in "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, or as published by the US Environmental Protection Agency. The Contractor shall submit to the Engineer a comprehensive report of the above sampling and analysis, including details of each analytical test as well as a summary of all the data and results in a Microsoft Excel spreadsheet.

Criteria for Passing the Test After Completion

(1) Treated Effluent Quality Criteria

The Works shall be deemed to have met the Treated Effluent Quality Criteria if:

(i) at least 95 percent of the plant effluent samples described above meet the requirements specified under the "Effluent Quality Requirements" sub-section of Volume 2, Section 7, Part 5, and

(2) Operational Cost Criteria

The plants shall have fulfilled the operating cost criteria if the operating costs determined during the Tests After Completion are in agreement with or less than those detailed in the Contractor's Functional Guarantee or an amount of liquidated damages are agreed by the Contractor and the Engineer to compensate for any short fall in performance up to an agreed maximum amount if stated.

(3) Plant Reliability Criteria

A part of the Works shall be deemed to have failed its test if:
(1) A single item of Plant / equipment fails more than twice during the test.
(2) More than four individual Plant items / equipment fail.

An item of Plant / equipment shall be deemed to have failed if manual intervention is required in order to restore the Plant / equipment to its fully operational state: i.e. the failure of a duty drive will be considered as one failure, if the standby drive fails to start that will be considered as a second failure.

14.30 Performance Certificate

The conditions for issuance of a Performance Certificate as detailed in Clause 45.2 of the Special Conditions of Contract shall inter alia comprise:

a) The completion of the six months operation of the Works (Tests after Completion) to the satisfaction of the Engineer.
b) The O & M Manuals have been updated following one year's operational experience and approved by the Engineer.
c) All defects identified prior to Taking Over and defects identified during one year operation of the Works have been rectified.
d) All Tests "After Completion" have been completed to the satisfaction of the Engineer.
e) All training detailed in the Employer's Requirements has been completed.

End of Part 14